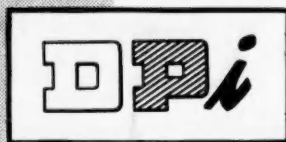


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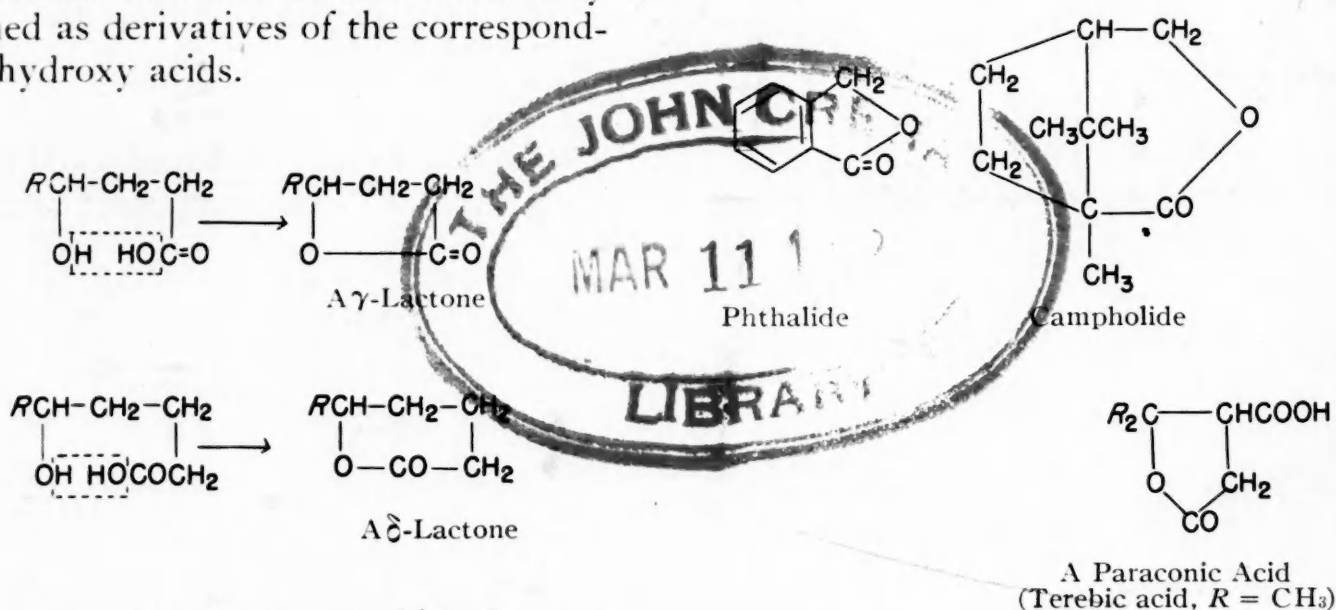
Lactones

By C. F. H. ALLEN*

Many hydroxy and halogenated acids, in which the hydroxyl (or halogen) and carboxyl groups are in appropriate positions, lose the elements of water (or halogen acid) to form inner esters which are called lactones. If the heterocycle so formed has five ring members, it is called a *gamma*-lactone, having been derived from a *gamma*-substituted acid, and if six, a *delta*-lactone. Lactones are usually named as derivatives of the corresponding hydroxy acids.

encountered by the organic chemist.

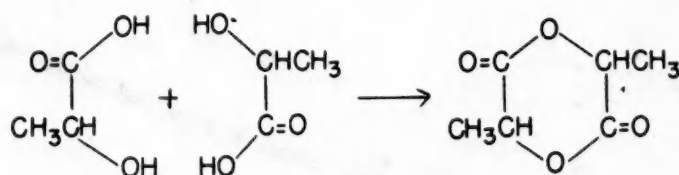
Lactones often contain carbocyclic rings, e.g., phthalide, campholide, and coumarin, and the paraconic acids, of which terebic acid is the best known. Most of these have been useful for synthetic purposes in connection with the theories of organic chemistry.



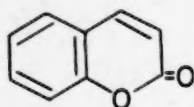
In a very few instances, the Geneva name, formed by adding "-olide" to the name of the appropriate hydrocarbon, is used.

When there is a possibility of either a γ - or a δ -lactone (e.g., the sugar series), a γ -lactone is preferentially formed. Gamma-lactones form so easily that the open-chain acid can seldom be isolated, whereas many δ -hydroxy acids can be isolated. Lactones having other-sized rings are known, but none are commonly

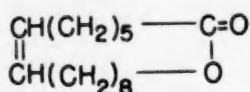
A lactide is a dilactone, formed on heating an α -hydroxy acid; two molecules of acid form one of lactone.



Lactones may be unsaturated, having double bonds in the ring, e.g., the angelicalactones, coumarin, and Ambrettolide.

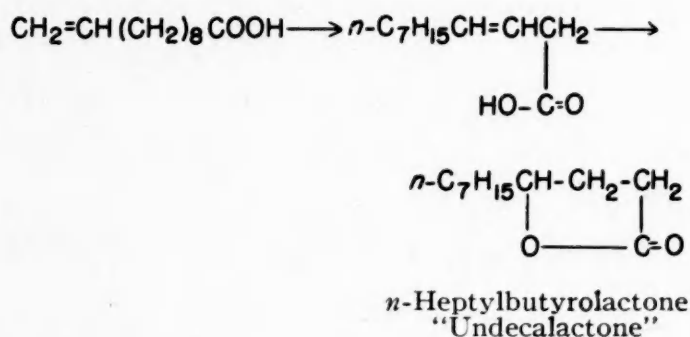


Coumarin

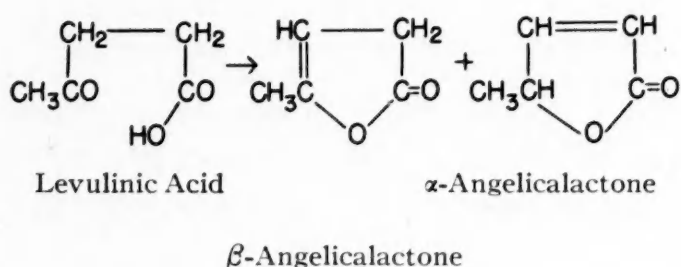


Ambrettolide

As previously mentioned, γ - and δ -lactones are readily formed spontaneously from γ - and δ -hydroxy or γ - and δ -bromo acids. They can be prepared in several other ways. For instance, when β,γ -unsaturated acids are treated with concentrated sulfuric acid, γ -lactones are formed by an intramolecular addition; the reaction is not reversible. A double bond may even migrate along a chain until it is in the β,γ -position, so great is the tendency to form a γ -lactone; the outstanding instance is that of undecylenic acid, which forms *n*-heptylbutyrolactone, the "aldehyde C_{14} " of the perfumer.



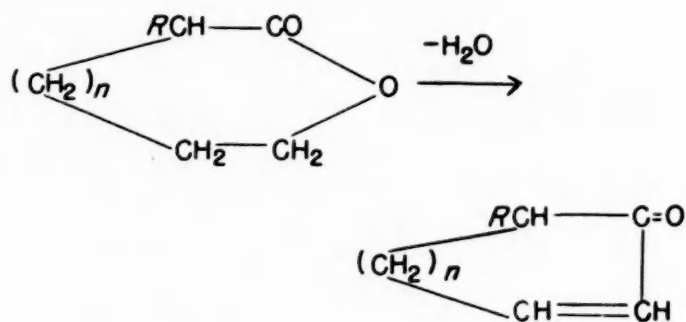
Suitably constituted ketonic acids lose the elements of water on heating or when treated with dehydrating agents to form unsaturated γ -lactones; levulinic acid gives the angelicalactones.



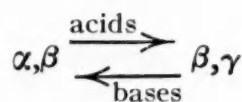
Lactones can be obtained by oxidation of cyclic ketones, using Caro's acid (H_2SO_5); this reaction has commercial importance in the production of Exaltolide and Ambrettolide. Many-membered lactones are also prepared by the intramolecular dehydration of ω -hydroxy acids.

Beta-lactones have been known for a long time; Staudinger showed that they resulted from the addition of ketenes to aldehydes and ketones. Beta-propiolactone has become available recently, being formed by the interaction of formaldehyde and ketene. The dimeric form of ketene, diketene, is considered to be a β -lactone.

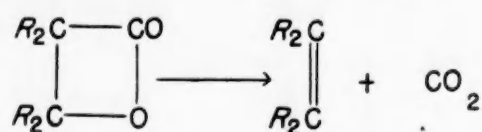
Lactones are insoluble in aqueous sodium carbonate but dissolve in sodium hydroxide solution, forming the salt of the corresponding hydroxy acid. Since lactones are (inner) esters, their chemical properties are, in general, like those of other esters, e.g., they react, by addition, with two equivalents of the Grignard reagent. The ring is opened by potassium cyanide at elevated temperatures, to give cyano acids. Many lactones lose water when heated in contact with activated earths, to give unsaturated ketones.



Many saturated lactones can be isomerized by acidic and basic reagents.



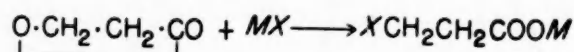
The most characteristic reaction of Staudinger's β -lactones is the easy elimination of carbon dioxide on heating.



The reactions of β -propiolactone have been established mostly by Gresham and co-workers. The lactone ring is readily opened by most reagents, the mode of opening depending upon the nature of the catalyst. In general, the products formed are β -substituted propionic acids, or substances resulting from their further reactions. In most instances, more or less polymeric ester acids also are formed.

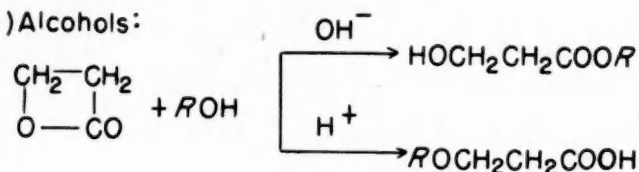
A few examples of the reactions of β -propiolactone are illustrated below:

(a) Salts:

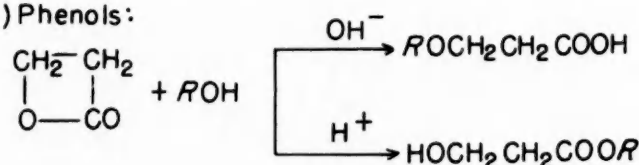


e.g., sodium chloride, acetate, sulfide, ammonium dithiocarbamate, magnesium bromide

(b) Alcohols:



(c) Phenols:



Uses

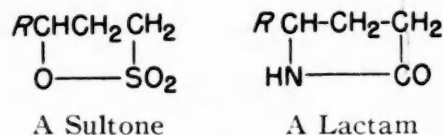
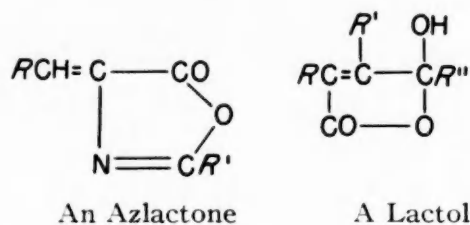
Many lactones are used in perfumery, e.g., α - and γ -alkyl lactones, such as several of the above, "aldehyde C₁₈" (which is *n*-amylbutyrolactone), and coumarin. Some are physiologically active, as protoanemonin and the cardiac aglucones. Many have been used in syntheses.

Related Compounds

There are several series of compounds related to lactones. Azlactones contain

nitrogen as well as oxygen in the ring; they have been widely used for syntheses of certain amino acids.

Lactols are a special type of hydroxy lactones that are formed by what amounts to an intramolecular addition of a carboxyl to a ketonic group. Most of the known lactols are highly substituted, have a five-membered ring, and are unsaturated. Sultones are intramolecular esters of hydroxysulfonic acids. Lactams may be considered as lactones in which the heterocyclic oxygen is replaced by an NH- or NR-grouping.



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Sodium Diethyldithiocarbamate as an Analytical Reagent

By C. W. ZUEHLKE*

Sodium diethyldithiocarbamate has become, in recent years, a preferred reagent for the determination of small amounts of copper. It offers a high order of sensitivity, and the possibility of extracting the colored copper complex tends to make the method broadly applicable. Although Sandell (Ref. 1) has cautioned that it is not a specific reagent for copper, the recent literature indicates that the extent of interference by a number of relatively common elements is not clearly understood. Sandell pointed out that bismuth, nickel, cobalt, uranium, and ferric iron form colored, extractable complexes which interfere unless appropriate steps are taken. The use of ammoniacal citrate solution effectively masks the effect of uranium and small amounts of iron. Dimethyl glyoxime may be used conveniently to eliminate cobalt and nickel. The interference of bismuth is not as easily avoided but Drabkin (Ref. 2) has suggested that the determination can be carried out on two samples, one of which contains added cyanide which prevents the formation of the copper complex. The copper content may then be calculated by difference.

A significant paper by Lacoste, Earing, and Wiberly (Ref. 3) on the analytical use of this reagent has appeared recently, in which it is pointed out that, in addition to the metals mentioned above, ferrous iron, hexavalent chromium and molybdenum, as well as divalent and tetravalent tin, form colored complexes which are extractable by chloroform. These authors have measured the relative sensitivity of the reagent for the various interfering ions which they place in the following order of decreasing sensitivity: cupric, nickelous, ferric and ferrous, bismuth, uranyl, cobaltous,

and dichromate. The extent to which these ions interfere in the copper determination depends greatly on the wave length of which the measurement is made. The color of the molybdenum and tin complexes fades rapidly and cannot be measured readily.

Lacoste, Earing, and Wiberly point out that, aside from their potential interference in the determination of copper, each of the metals in this series actually can be determined by the use of sodium diethyldithiocarbamate. In the case of iron, nickel, and chromium, for which a number of entirely satisfactory methods are available, this may be a matter of relatively little importance. In the case of uranium and especially cobalt and bismuth, however, the "carbamate" method offers interesting possibilities.

A close similarity can be noted between the "carbamate" method and the well-known dithizone extraction procedures. Although dithizone reacts with many metals, a remarkable selectivity can be achieved by the use of appropriate masking reagents. A further study on the use of masking agents applicable to the carbamate method provides an interesting field for investigation. The combined application of these two reagents should prove increasingly useful to the analytical chemist.

*Research Laboratories, Eastman Kodak Company, Rochester 4, New York.

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